This page provides instructions for use of the Delphes card for CLICdet. The performance of the card as well as instructions for use are described in https://arxiv.org/abs/1909.12728 .

Jets in the CLICdet Delphes card

At linear colliders, rather large cone size parameters (R) can be used for jet algorithms, regardless if using kt or VLC etc. This is due to the lower levels of soft interaction background (pile-up).

However, it implies that more often than for lower R jets, the jets have a substructure of lower R jets, i.e. two jets are merged. At analysis level, this is usually crucial information, e.g. for suppression of backgrounds with a slightly different jet multiplicity or in order to use the correct objects for invariant masses.

Therefore, jet clustering is often run in "exclusive mode" (see FastJet manual), usually with a fixed number of jets. This forces the algorithm to stop when a certain number of jets has been clustered, thus revealing the substructure information directly.

In order to accomodate for a range of jet multiplicities that might be useful for the analyses conducted here, the Delphes card for CLICdet contains N=2,3,4,5,6 jets algorithms with 5 different R parameter values. (Of course more can be added). The user should pick the one most suitable for their analysis. As a rule of thumb, N should of course correspond to the number of partons expected in the tree level final state. R can be large for low center-of-mass and slightly reduced for higher center-of-mass due to higher levels of background.

⚠ Upshot: Use large R radii, e.g. 1.2 or 1.5 for Stage 1, 1.0 or 1.2 for Stage 2, and 0.7 or 1.0 for Stage 3. To avoid loosing the jet substructure through the large radius, use exclusive Njets clustering

Flavor tagging

B-tagging

B-tagging is implemented in the card with 3 working points (WP), which tag 50%, 70%, and 90% of all b-quark-initiated jets, respectively. The corresponding mis-tagging rates are implemented in the CLICdet card. Delphes uses different bits to store the b-tagging information in the following way, where bit 0 is the tight WP with 50% tagging efficiency, bit 1 is the medium WP with 70% efficiency, and bit 2 is the loose WP with 90% b-tagging efficiency. This leads to the following combinations:

BTag value	7	6	5	4	3	2	1	0
BTag binary	111	110	101	100	011	010	001	000
(bit 0) & BTag	T	F	T	F	T	F	T	F
(bit 1) & BTag	T	T	F	F	T	T	F	F
(bit 2) & BTag	T	T	T	T	F	F	F	F

In summary, to require loosely b-tagged jets, please choose in the Jet TBranches of the output ROOT files the values BTag>=4; for medium b-tagged jets, require the BTag to be one among 2, 3, 6, and 7, and for the tight WP the BTag should be 1, 3, 5 or 7.

⚠ This does not correspond to the PGS4-based LHCO format defaults.

C-tagging

The c-tagging capabilities of CLICdet are not yet implemented in the CLICdet Delphes cards. Please contact us if you would like to use it or have questions about the c-tagging performance. You can find the c-tagging performance in https://arxiv.org/abs/1812.07337 , Sec. 4.2.6.

Taking into account the effect of gamma gamma -> hadrons background

The effect from gamma gamma -> hadrons background is more severe at the high energy stages, `Stage2` and `Stage3`. To account for its effects, a jet energy smearing and scaling is applied in those two cards. The branches with these effects applied are then named

```
JES_VLCjetR<r>N<njets>
```

in the resulting root file.

Setup Madgraph to use the CLICdet Delphes card

The CLICdet card is a part of the central git repository. The following instructions show how to use Madgraph with the Delphes code if one wishes to do local modifications of the cards (or in case there is a newer version not yet shipped by MadGraph).

- Set up the software environment as you would for Madgraph (ROOT etc)

e.g. on lxplus:

```
source /cvmfs/clicdp.cern.ch/iLCSoft/builds/current/CI_gcc/init_ilcsoft.sh
```

The card has been tested with ROOT 6.08.00.

- Work in some directory, whose absolute path is meant by

  ```
  <BASEDIR>
  ```

  in the following instructions

- Clone the Delphes repo from github:

```
cd <BASEDIR>
git clone https://github.com/delphes/delphes.git
cd delphes/
make
```

- In case you have not installed Madgraph yet:
  - ♦ Download Madgraph from http://madgraph.phys.ucl.ac.be/ (needs account)
  - ♦ Untar with

```
tar -xvzf MG5_aMC_v2.6.1.tar.gz
cd MG5_aMC_v2_6_1/
```

- Modify the configuration file `input/mg5_configuration.txt` : The line

```
 # delphes_path = ./Delphes
```

needs to be changed to

```
delphes_path = <BASEDIR>/delphes
```

(note that the # in the beginning must be removed)

- Start Madgraph with

```
cd MG5_aMC_v2_6_1/
./bin/mg5_aMC
```

to check that it is taking the right delphes:

```
>display options delphes_path
```

- Copy the respective delphes cards to the Template directory. There are 3 cards for the 3 energy stages of CLIC. Please choose the one appropriate for your scenario:

Stage	Energy
Stage1	380 (350) GeV
Stage2	1.5 (1.4) TeV
Stage3	3 TeV

```
cp <BASEDIR>/delphes/cards/delphes_card_CLICdet_StageN.tcl Template/Common/Cards/delphes_card.dat
```

and

```
cp -r <BASEDIR>/delphes/cards/CLIC/ Template/Common/Cards/
```

where `StageN` can be `Stage1`, `Stage2`, or `Stage3` depending on the center-of-mass energy as indicated in the table.

- If you use the LHCO file format in your analysis chain: Decide which jet clustering parameters to use. For advice, check #AWordAboutJets below. Once you know which N and R values you like, change the corresponding line in the `TreeWriter` module at the end of the card `Template/Common/Cards/delphes_card.dat`, e.g. if you decide your analysis needs N=4 and R=1.0 jets:

```
add Branch FastJetFinderVLC_R10_N4/VLCjetsR10N4 VLCjetR10N4 Jet
```

should be modified to:

```
add Branch FastJetFinderVLC_R10_N4/VLCjetsR10N4 Jet Jet
```

- Install Pythia (if you have not already)

```
>install pythia8
```

- Generate your favorite process and its output

```
>generate e+ e- > h z > b b~ j j
>output PROCESS
```

- Exit the MG5 prompt and proceed as usual

```
cd PROCESS
./bin/generate_events EVENTDIR
```

when prompted for it, apply:

```
>detector=ON
```

- A root file `tag_1_delphes_events.root` can be found in the `Events/EVENTDIR` folder.

Setup Madgraph to use the CLICdet Delphes card   3

- When the Delphes code has changed, change to the `< BASEDIR >/delphes/` directory and do

```
git pull
make
```

Contact and references

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The CLICdet Delphes card is described in https://arxiv.org/abs/1909.12728 . Please quote this paper when you use the card.

The performance of CLICdet is described in https://arxiv.org/abs/1812.07337 . The detector concept is described in detail here: CLICdp-Note-2017-001

-- UlrikeSchnoorSecondary - 2018-02-15

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